International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 9, Issue 3, Jun 2019, 1323-1334

EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE OF CI ENGINE USING WASTE PLASTIC PYROLYSIS OIL (WPPO) WITH THERMAL BARRIER COATING ON PISTON AND THERMAL ANALYSIS OF THE PISTON USING ANSYS

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ABSTRACT

In the machine-driven world, cars are taking part in the key role in travelling individuals to their destinations. With the boost in transport population, the need for fuel is skyrocketing and also the emphasis is ordered on increasing the performance of the internal-combustion engine by mistreatment, totally different blends with diesel and piston coatings. This work is to associate experimental investigation to look at totally different parameters like brake thermal efficiency, brake specific fuel consumption etc., of a internal-combustion engine that makes use of oil derived from the shift, de-polymerization and condensation of dead plastics. The waste plastic transformation oil obtained is mixed with diesel and also the blend is employed as fuel in internal-combustion engine. 5 blends were created within the quantitative relation of 90-10, 80-20, 70-30, 60-40, 50-50 share of diesel and WPPO severally. These blends were tested in engine doubly once with associate uncoated piston and next with a piston coated with zirconium dioxide.

KEYWORDS: ***Diesel Engine, WPPO Blends, Ceramic Coating, Zirconates & Engine Performance***

Received: Apr 19, 2019; **Accepted**: May 09, 2019; **Published**: Jun 01, 2019; **Paper Id.**: IJMPERDJUN2019138

Original Article

INTRODUCTION

There are several pollutants that are haunting the atmosphere; one such common waste matter is the waste plastics. Plastic waste blocks the drain by stopping the flow of rain water and waste product, inflicting an overflow that becomes the piece of ground for bacterium and germs that cause diseases. The cyanogenetic smoke created whereas burning plastics kills thousands every year.

India is watching renewable various fuel sources to scale back its dependence on foreign import of oils. As India imports seventieth of the oil, the country has been hit laborious by increasing price and uncertainty. The employment of those fossil fuels results in serious environmental problems like pollution. They additionally emit monoxide, dioxide, pollutant etc., when burnt. Therefore, various fuels are the sole supply to resolve the matter of world warming and energy crisis.

Plastic waste usage will give a chance to gather and eliminate plastic waste within the most environmental friendly method, and it may be regenerate into a resource. Thermoplastic wastes may be recycled. Usage of thermosetting materials is tougher attributable to the properties of those materials, however they are recycled

as fuel and are used generally, by grinding, as fillers within the new thermosetting materials.

WASTE PLASTIC PYROLYSIS OIL

Plastics are non-biodegradable polymers which contains carbon, hydrogen, and few other elements. They are typically consisting of high molecular mass, and may contain other substances besides polymers to improve performance and/or reduce costs. Plastics are converted into liquid fuel by a process called pyrolysis. Pyrolysis is a process of thermal degradation in the absence of oxygen. Plastic and Rubber waste is continuously treated in a cylindrical chamber and the pyrolytic gases are condensed in a specially-designed condenser system and are converted into three products i. e., solid fuel into coke, liquid fuel into combination of gasoline, kerosene, diesel and lube oil and gaseous fuel in to LPG range gas.

WPPO PROPERTIES

The Waste plastic pyrolysis oil, which is derived from the pyrolysis process, is tested and the properties of it compared to diesel are as follows:

Table 1: Comparison of Diesel with WPPO

Comparison of Diesel with WPPO				
S. No	Property	Units	Diesel	WPPO
1	Sp. Gravity @ 15^0 C	-	0.81 -0.96	0.8342
2	Flash point	^{0}C	52 – 96	55 – 60
3	Calorific Value	Kcal/kg	11000	10186
4	Viscosity @ 40 ^{0}C	mm^2/ sec	1.62	1.021
5	Density	Kg/m^3	810 -960	834.2

THERMAL BARRIER COATING

Thermal barrier coatings are duplex systems consisting of a ceramic topcoat and a metallic intermediate bond coat. Thermal barrier coatings help to achieve higher efficiency of combustion engines (internal combustion engines and gas turbine engines) due to an increase of their operating temperature.

The topcoat consists of ceramic material whose function is to reduce the temperature of the underlying, less heat resistant metal part. The bond coat is designed to protect the metallic substrate from oxidation and corrosion and promote ceramic topcoat.

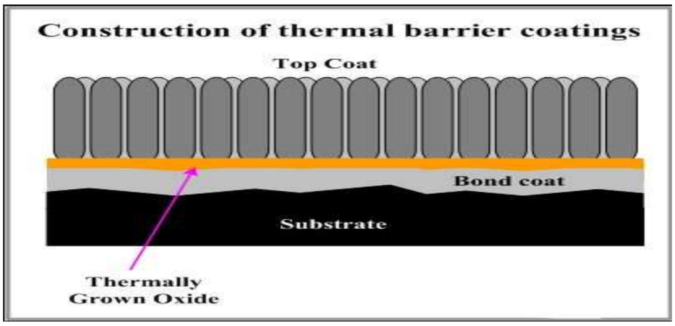

Figure 1: Thermal Barrier Coating

Here, zirconates are used as thermal barrier coating. The principle points of interest of zirconates are low sintering movement, low warm conductivity and high warm development coefficient. The fundamental issue is high warm development coefficient, which results in left over anxiety in the covering and this can bring about delamination.

Thermal Analysis

Static steady state thermal analysis is done on the piston to see the temperature variation on the piston head with and without coating the thermal barrier. Boundary conditions for the piston are obtained from the literature. The temperature values in the cylinder are taken from the average of four cycles. The following are the key assumptions that were made for the thermal analysis.

Key Assumptions

- Heat transfer due to convection of oil film is neglected.
- All materials are assumed to be isotropic and linearly elastic.
- The influence of piston movement on temperature is neglected.
- The inner temperature of the gas was taken as the mean temperature results on suction, compression, and combustion and gas expulsion temperature in the course of engine operation.

EXPERIMENTAL SETUP AND PROCEDURE

This experimental setup consists of four stroke diesel engine connected with electrical loading. By using this setup, we estimated the performance for different loading conditions with different WPPO blends along with piston coating and without piston coating.

The engine specifications are:

Bore: 80mm	Dia of Brake drum: 360mm
Stroke: 110mm	Thickness of Belt: 5mm
RPM: 1500	Coefficient of discharge: 0.6
BHP: 5	Dia of orifice: 20mm

Compression Ratio: 16:1 Maximum Current: 13 amps

Generator Efficiency: 80%

Test Rig

Figure 2: A Four Stroke Diesel Engine with Generator Loading

Experiment Procedure

Initially, the engine is made to run with diesel for duration of 10 to 15 minutes before using WPPO blends, in order to attain stable working environment. After that, diesel fuel is completely drained out from the fuel tank and then the sample of WPPO – diesel blends are poured into the fuel tank. It is important to note whether the engine has attained its optimum temperature conditions. At constant speed of 1500 rpm, engine is loaded with 0%, 5%, 25%, 50%, 75%, 100% load by using an eddy current dynamometer. The blends are tested at all load conditions running at constant speed, where the experimental procedure is same for every proportion to be tested.

Procedure for ANSYS

First, the piston is designed in CATIA with available dimensions. Thermal analysis is performed by using the FEA software ANSYS, produced by ANSYS Inc. Static steady state thermal is chosen form the tool box. The properties of aluminium and ZrO2 are added and/or retrieved if earlier present in the system engineering data. The model is loaded in geometry tab by importing it in IGES or STP file type. The model tab is opened the appropriate materials are assigned to the components. Meshing is done to the model such that the model does not lose any key feature, the meshing is done using medium grain size. Then boundary conditions and temperatures are assigned to the model as shown in figures below. The average heat transfer coefficient and temperatures predicted as the boundary conditions are given in Figures below.

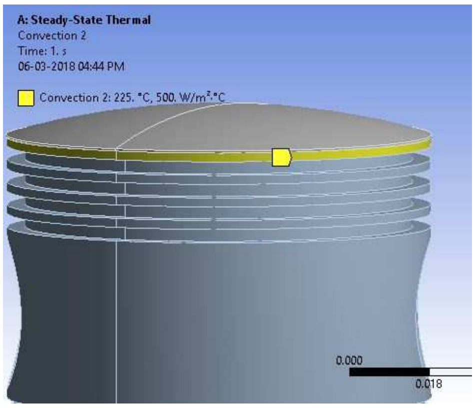

Figure 3: Boundary Condition 1

The boundary condition 1 for portion above the ring with temperature = 225 0C and convection heat coefficient as 500 W/m2 0C.

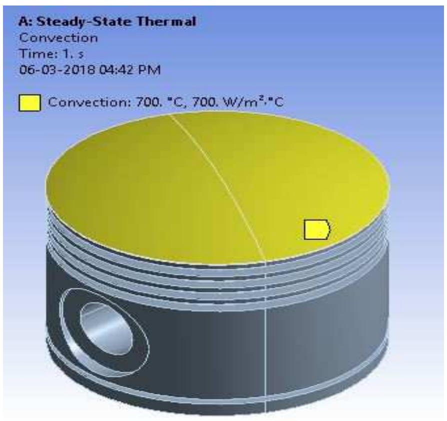

Figure 4: Boundary Condition 2

Boundary condition 2 for the top surface with Temperature = 700□ and convection heat coefficient as 700 W/m2□.

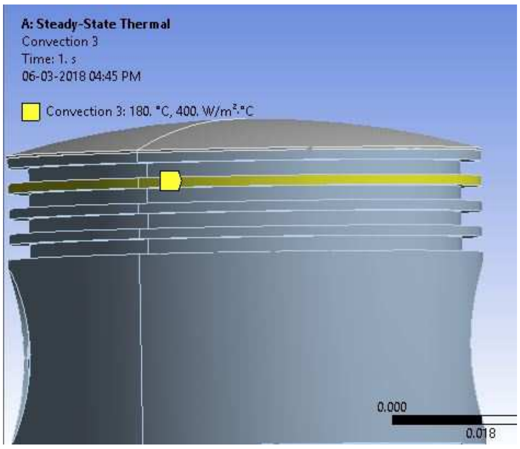

Figure 5: Boundary Condition 3

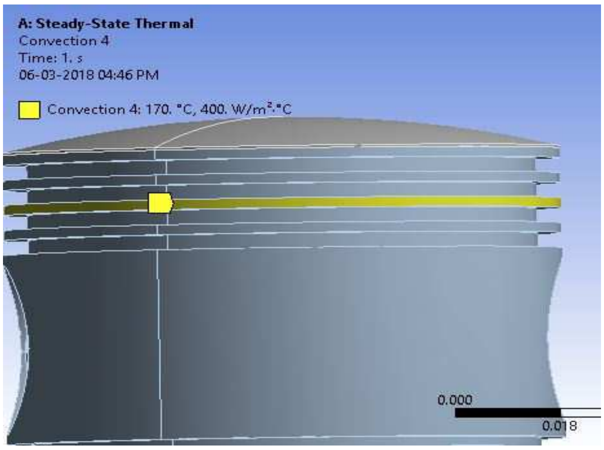

Figure 6: Boundary Condition 4

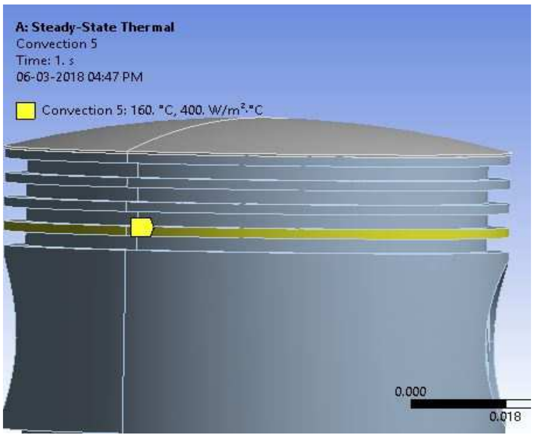

Figure 7: Boundary Condition 5

Boundary conditions 3, 4, 5 for the piston ring with Temperature = 180□, 170□, 160□ and convection heat coefficient as 400 W/m^2 □.

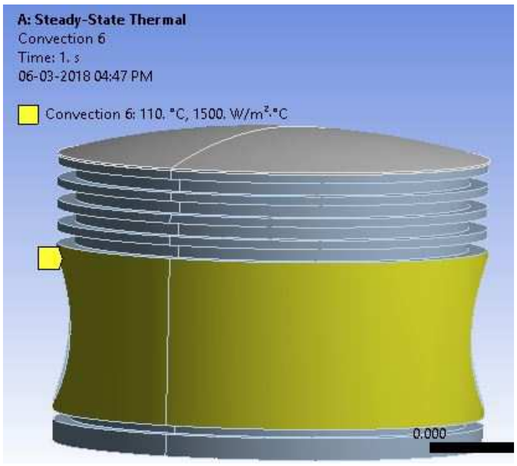

Figure 8: Boundary Condition 6

Boundary condition 6 for the outside portion with Temperature = 110□ and convection heat coefficient as 1500 W/m2.

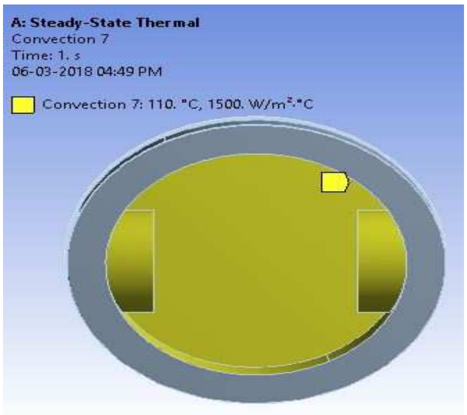

Figure 9: Boundary Condition 7

Boundary condition for the inside portion with Temperature=110□ and convection heat coefficient as W/m2 □.

These boundary conditions are given and solved for getting the temperature distribution for both coated piston and uncoated piston.

PERFORMANCE OF WPPO BLENDS WITHOUT PISTON COATING

The following is the plot drawn for Brake Power Vs Brake thermal efficiency at different loading conditions using different blends of WPPO and diesel for a normal engine.

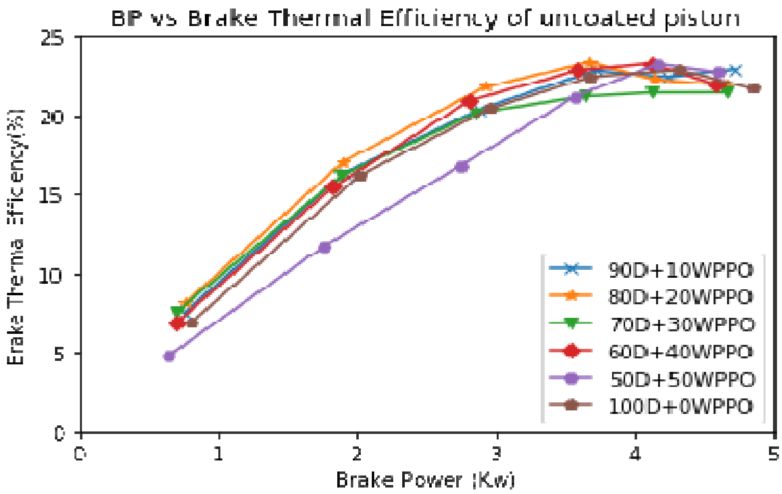

Figure 10: Brake Power Vs Brake Thermal Efficiency of Uncoated Piston

The following is the plot drawn for Brake Power Vs Indicated thermal efficiency at different loading conditions using different blends of WPPO and diesel for a normal engine.

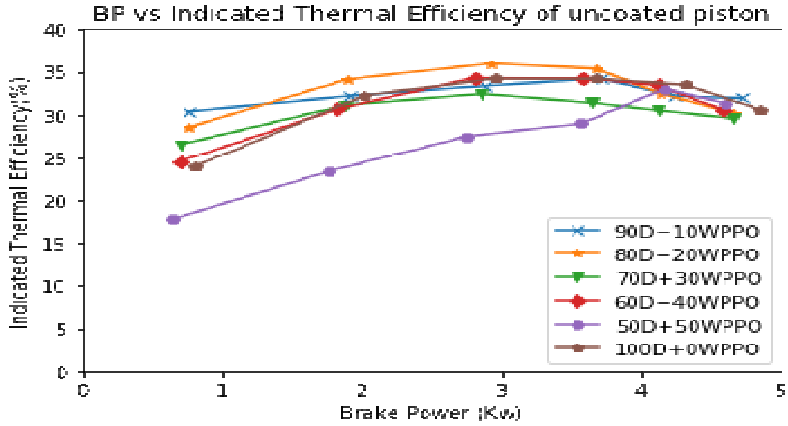

Figure 11: Brake Power Vs Indicated Thermal Efficiency of Uncoated Piston

The following is the plot drawn for Brake Power Vs Mechanical efficiency at different loading conditions using different blends of WPPO and diesel for a normal engine.

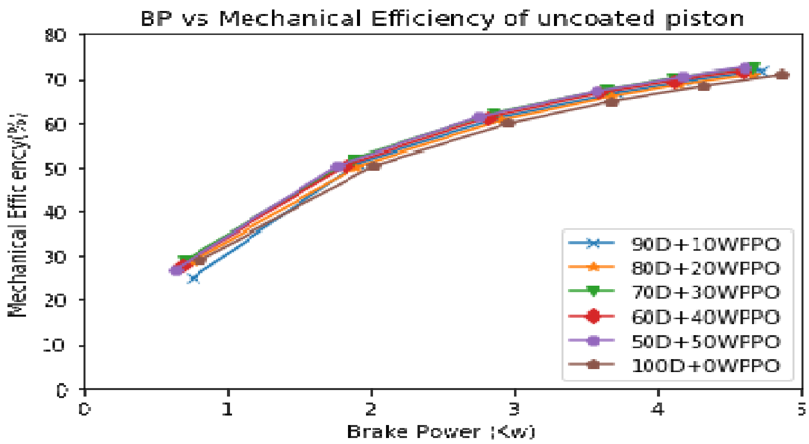

Figure 12: Brake Power Vs Mechanical Efficiency of Uncoated Piston

The following is the plot drawn for Brake Power Vs specific fuel consumption at different loading conditions using different blends of WPPO and diesel for a normal engine.

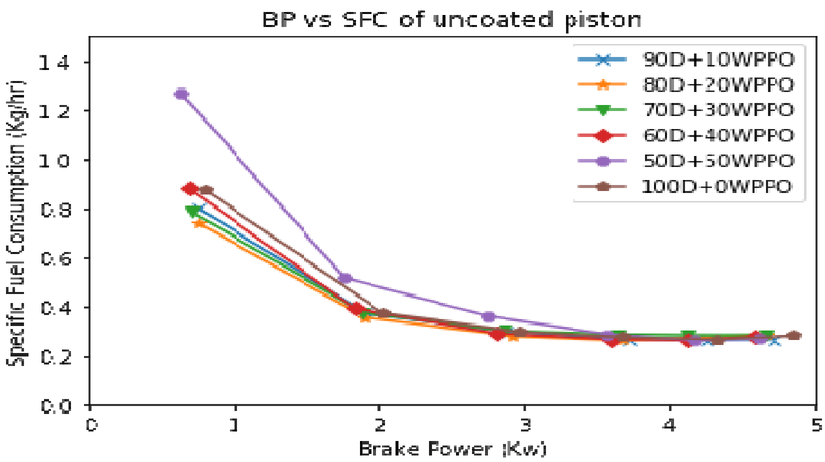

Figure 13: Brake Power Vs SFC for Uncoated Piston

From the graphs it is clear that the 80% diesel and 20% WPPO blend is giving better performance when compared to the other type of blends.

PERFORMANCE OF WPPO BLENDS WITH PISTON COATING

The following is the plot drawn for Brake Power Vs Brake thermal efficiency at different loading conditions using different blends of WPPO and diesel for an engine equipped with ZrO2 coated piston.

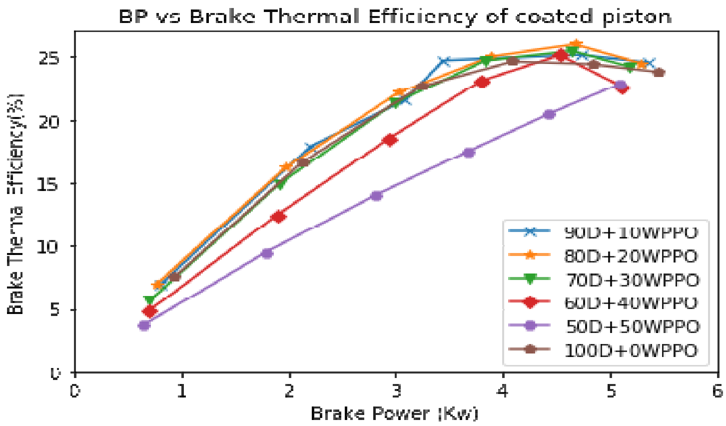

Figure 14: Brake Power Vs Brake Thermal Efficiency for Coated Piston

The following is the plot drawn for Brake Power Vs Indicated thermal efficiency at different loading conditions using different blends of WPPO and diesel for an engine equipped with ZrO2 coated piston.

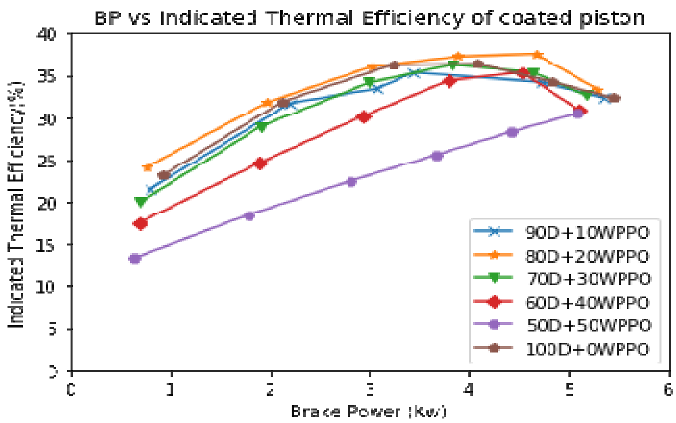

Figure 15: Brake Power Vs Indicated Thermal Efficiency for Coated Piston

The following is the plot drawn for Brake Power Vs Mechanical efficiency at different loading conditions using different blends of WPPO and diesel for an engine equipped with ZrO2 coated piston.

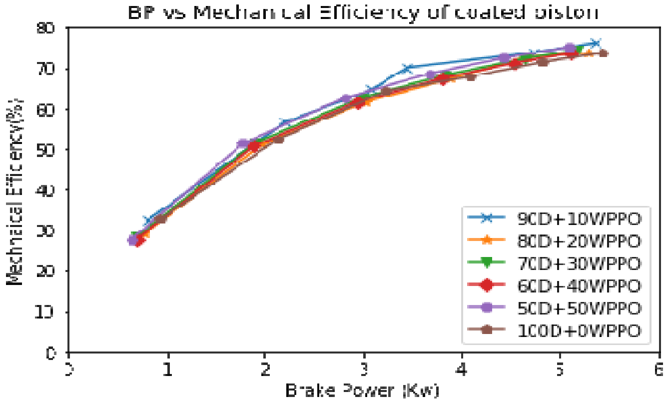

Figure 16: Brake Power Vs Mechanical efficiency for Coated Piston

The following is the plot drawn for Brake Power Vs specific fuel consumption at different loading conditions using different blends of WPPO and diesel for an engine equipped with ZrO2 coated piston.

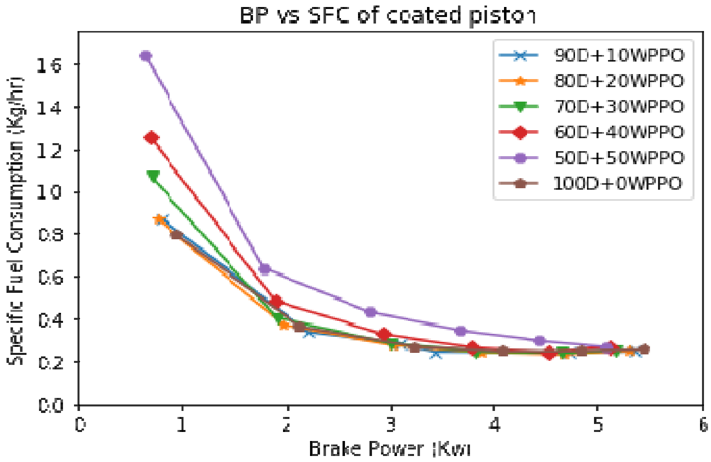

Figure 17: Brake Power Vs SFC for coated piston

From the graphs, we observe that the efficiencies of the engine has increased by 5% -10% and also the blend of 80% diesel and 20% WPPO has shown better performance than other blends in all aspects.

TEMPERATURE DISTRIBUTION

By applying the boundary conditions and by following the assumptions, thermal analysis is done to find the temperature distribution on the piston. The results are as follows.

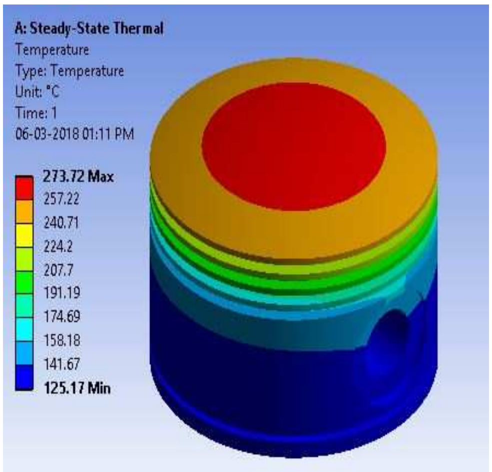

Figure 18: Temperature Distribution for Uncoated Piston

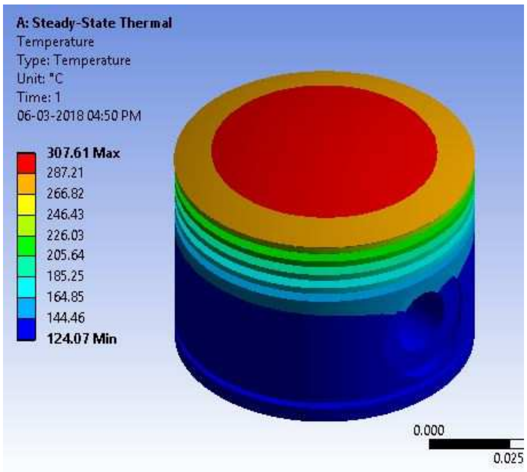

Figure 19: Temperature Distribution for Coated Piston

On seeing the pictures, we can say that the top crown temperature of coated piston has increased, and due to this, the internal temperature of engines increases resulting in better performance of the engine.

CONCLUSIONS

The WPPO blended with diesel can be used as alternative fuel in diesel engine. Five blends i. e. 90 - 10, 80 – 20, 70 – 30, 40 – 60, 50 – 50 percentages of diesel and WPPO were tested in an engine twice, once with an uncoated piston and next with a piston coated with zirconium oxide. It was found that by using 80% diesel and 20 % WPPO blend the performance of the engine is increased when compared to diesel. Further the piston coating increased the efficiency of the engine by 5 – 10% due to high thermal resistance. In economical point of view, it is advisable to use 80% diesel and 20% WPPO blend as fuel. The cost of WPPO is less and therefore it can be used as alternative fuel in diesel engine. On the whole the use of WPPO not only solves the problem of fuel shortage but also that of plastics.

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